

## DETTONATION SHOCK RADIUS EXPERIMENTS (BRIEFING CHARTS)

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### CONFERENCE BRIEFING CHARTS

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*2007 APS – 15<sup>th</sup> Topical Conference  
on Shock Compression of Condensed Matter, Hawai'i*

# **Detonation Shock Radius Experiments**

## **June 2007**

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# Outline



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- **Background**
  - Detonation Shock Dynamics
  - Hot Spot Size and Initiation
- **Characterization Experiments**
- **Summary**

## Acknowledgements

**Ed Wild and Lt. Martin, AFRL/MNMF**  
**Ken Jensen, Honeywell KCP**



# Detonation Shock Dynamics – 1<sup>st</sup> Order

University of Illinois, Prof. Scott S. Stewart



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- Relationship between local wave curvature and local normal detonation velocity

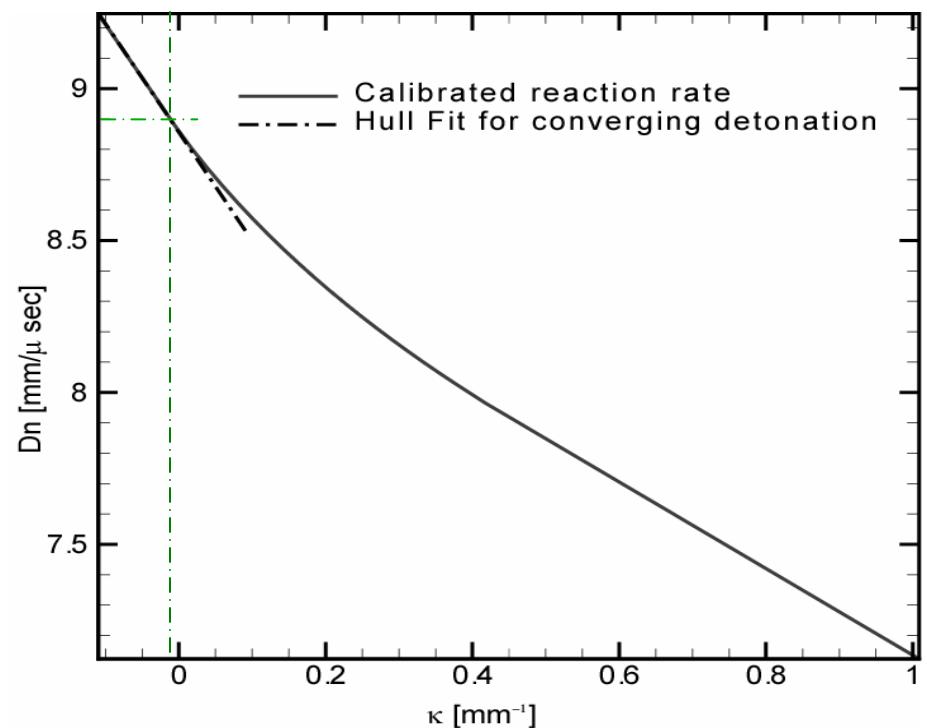
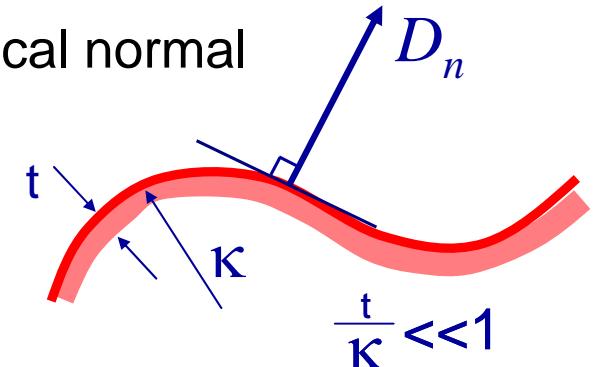
$$D_n = D_{CJ} (1 - \nu \kappa)$$

$$\kappa = \frac{f''(x)}{\{1 + [f'(x)]^2\}^{3/2}}$$

$D_{CJ}$  = steady state Chapman-Jouguet velocity

$\nu$  = empirical constant to curvature data

$\kappa$  = mean curvature of the detonation wave

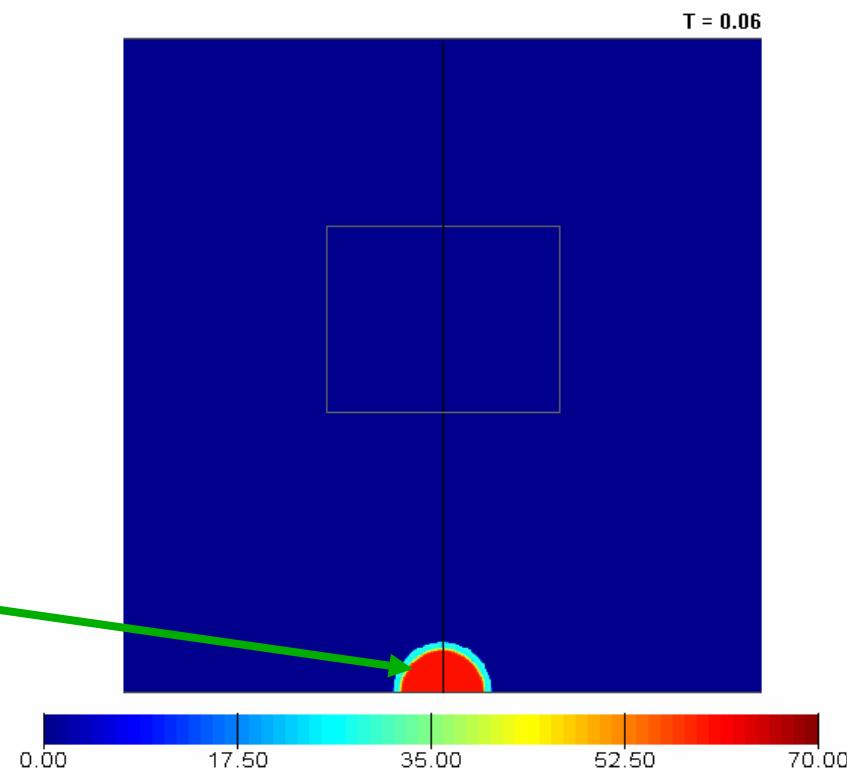
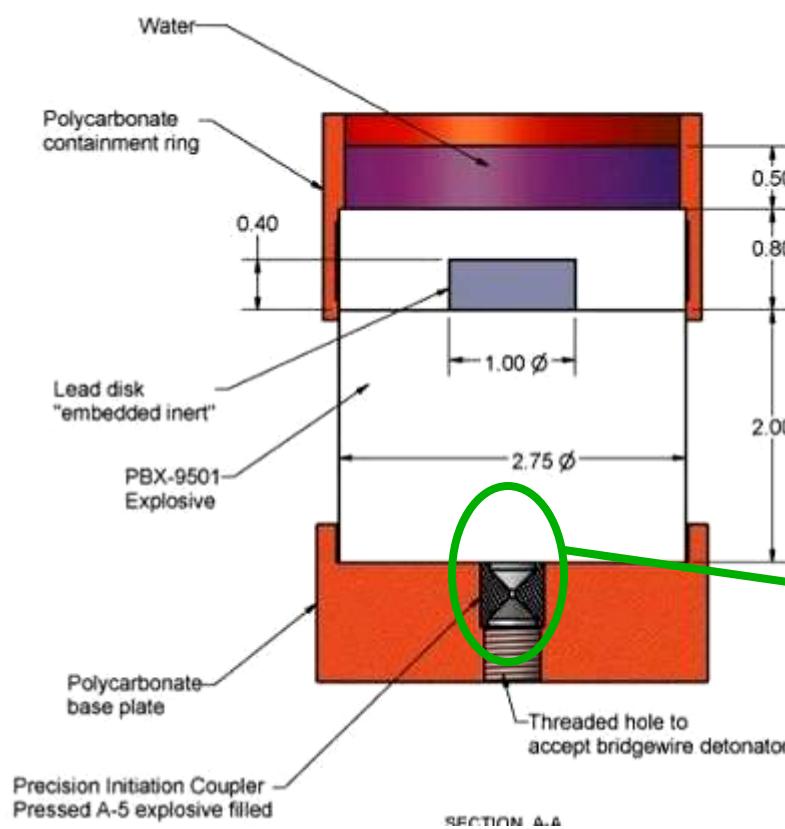




# “Passover” Validation Experiment

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- Single hemispherical wave transforms into a colliding toroidal structure
- Exercises the DSD wavetracking, EOS, and rate law over a wide range of detonation states
- Assumptions were made on the initial shock radius, starting point of the DSD waveform

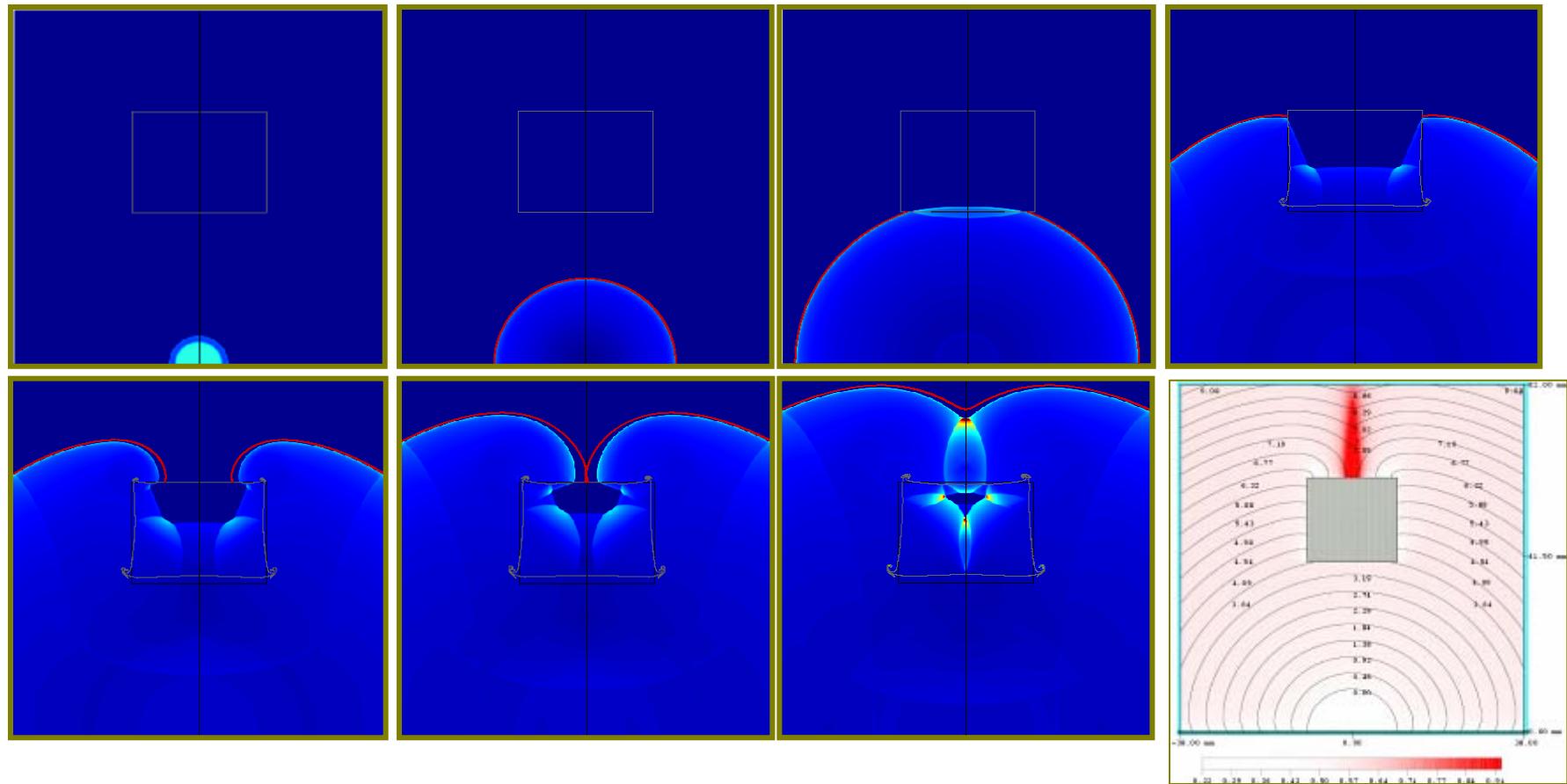




# Clips from “Passover” Experiment Video



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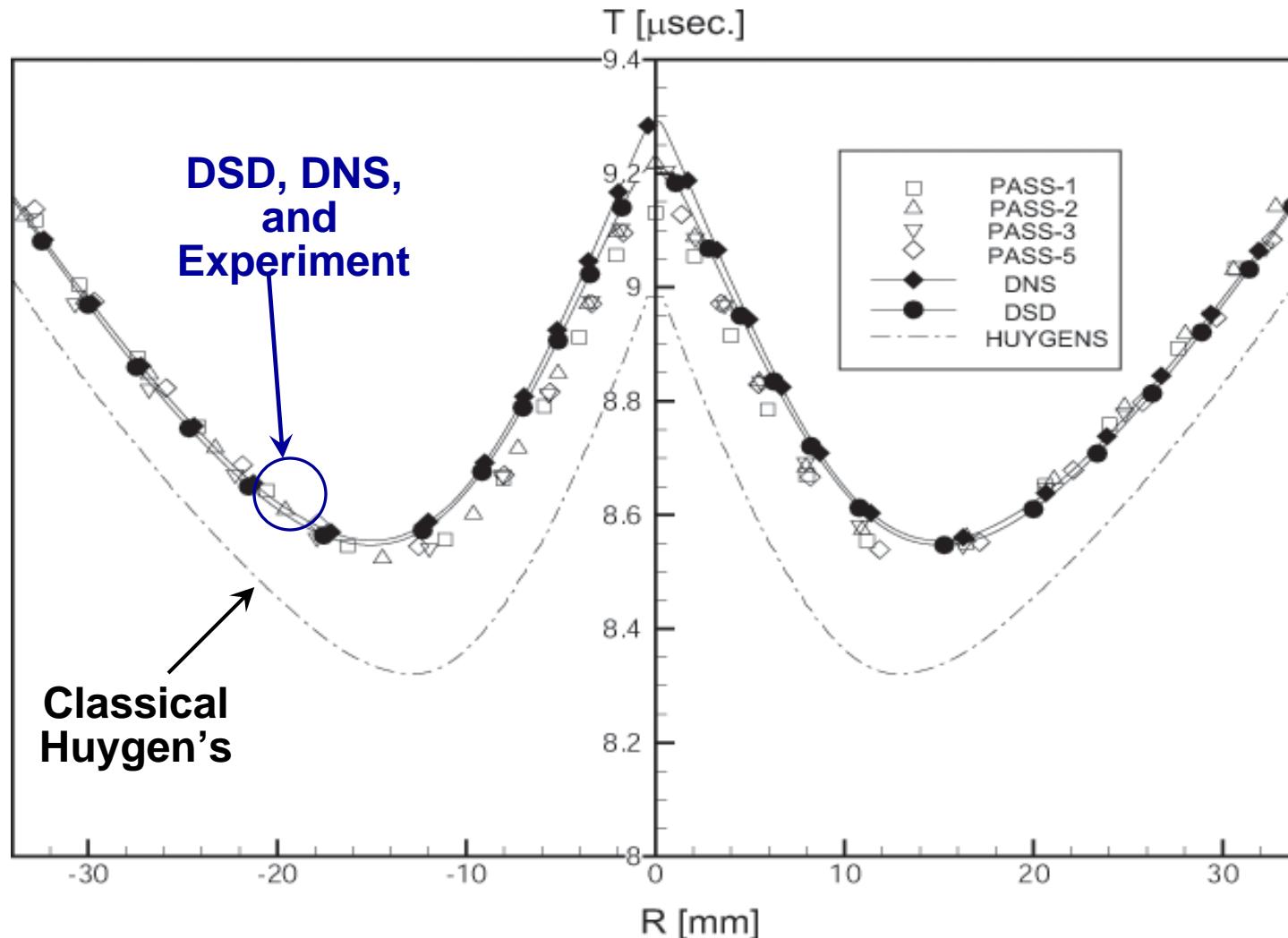




# Comparison of “Passover” Experiment

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Time-of-arrival record across the top surface of the charge

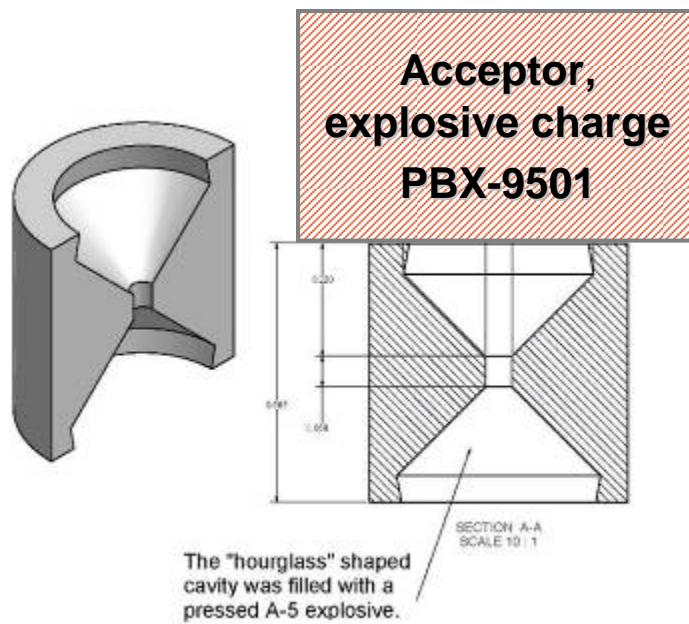




# DSD-based Initiation Size

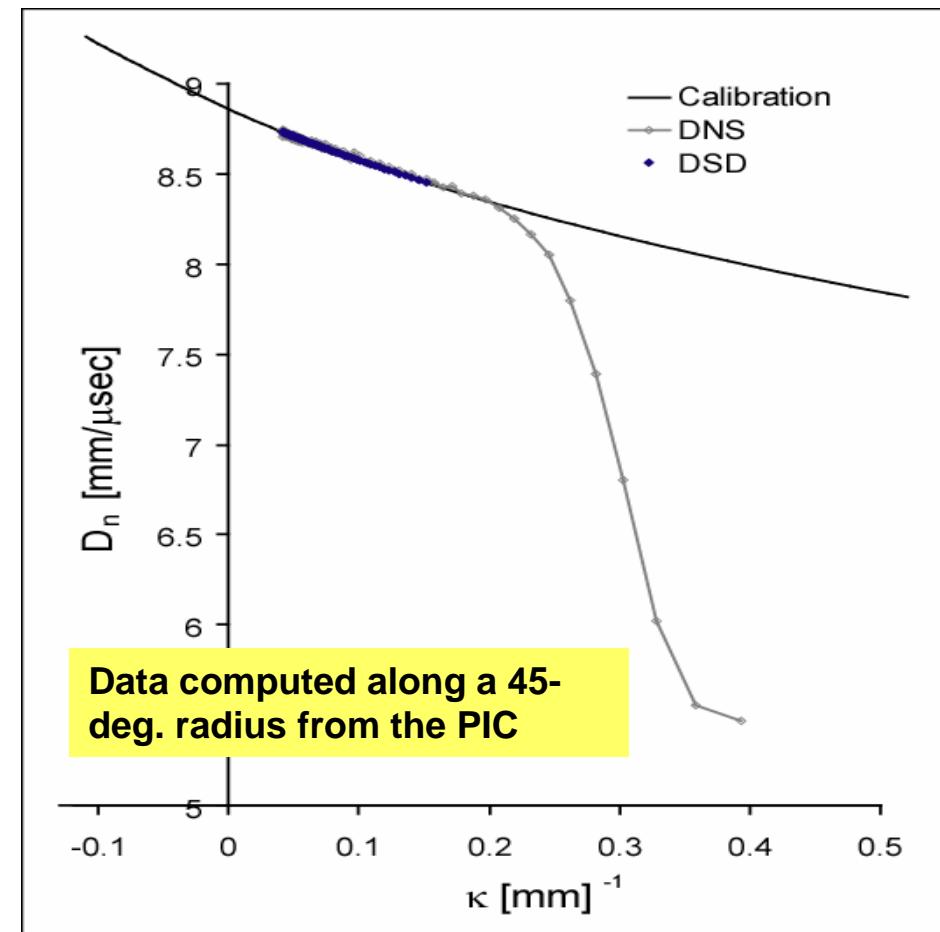
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- Initiation curvature and radius-growth to reach DSD-based assumptions and comparison to Direct Numerical Simulations



## "Precision Initiation Coupler (PIC)"

- Self-centering
- 680mg of Composition A-5 (98.5% RDX, 1.5% stearic acid)
- Near-point initiation (0.052")

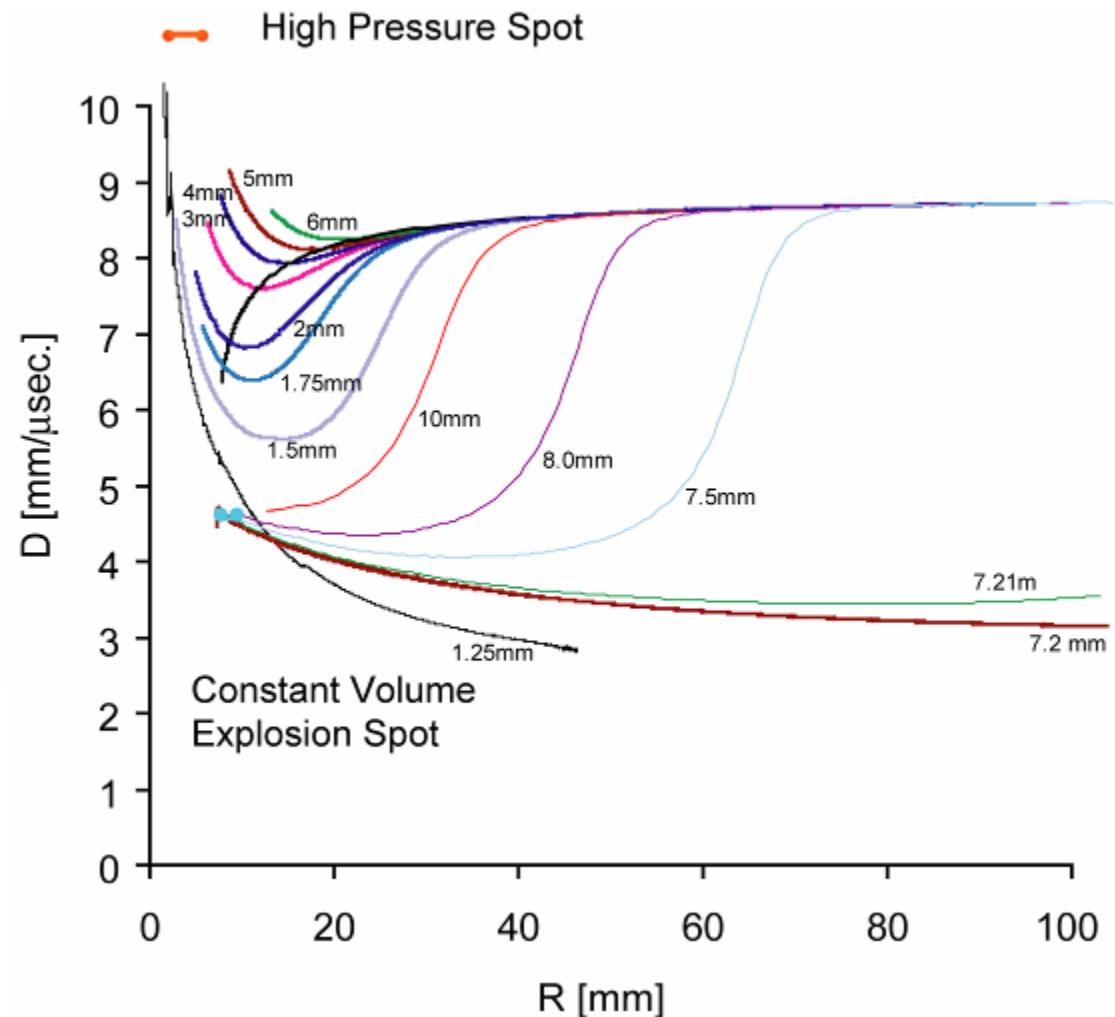
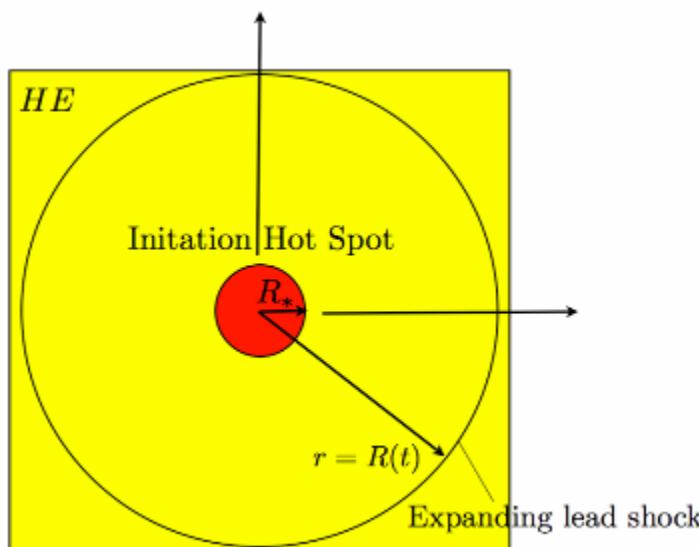




# Spot-Size / Initiation Radii

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- Simulated  $D_n$ - $R$  response for PBX-9501, initiated from various hot-spot radii, both spherical low pressure and high pressure.



**DETERMINATION OF THE LIGHTING RADIUS FOR  
DETONATION SHOCK DYNAMICS AND CRITICAL  
IGNITION TRANSIENTS IN CONDENSED EXPLOSIVES**

D. Scott Stewart, Sunhee Yoo, and David E. Lambert –  
2006 International Detonation Symposium



# Characterization Experiments



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**Objective:** Characterize the initial shock profile transmitted from the composition A-5 loaded Precision Initiation Coupler to PBX-9501 explosive charges

**Approach:** “Cut-back Technique” Obtain detonation shock front time-of-arrival data on small, rectangular prisms of explosives

- Time-of-arrival, wave front contour is the key data
- Streak camera and ultra-high speed digital imaging
  - Cordin 132a with 100 $\mu$  slit-width, 12mm/us writing rate, TMAX-3200 film
  - Imacon 200 Ultra-high speed framing camera at nominally 100-ns interframe time and 15ns duration
- PBX-9501 – initiated w/ RP-1 and A-5 PIC system. Needed initial radius for DSD

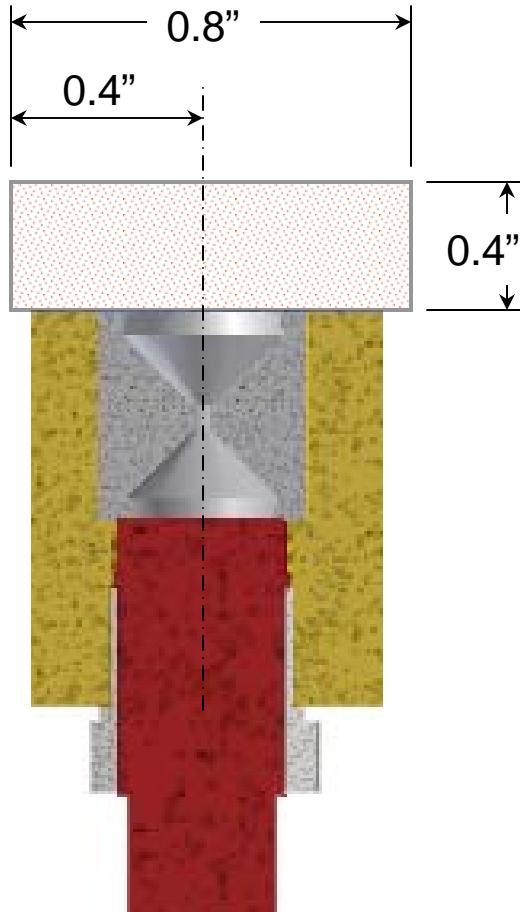


# Example Charge Configurations

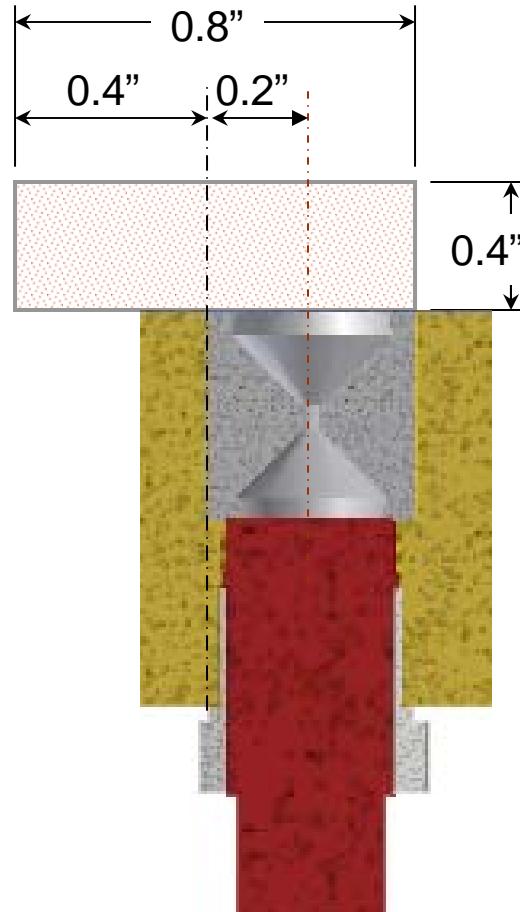


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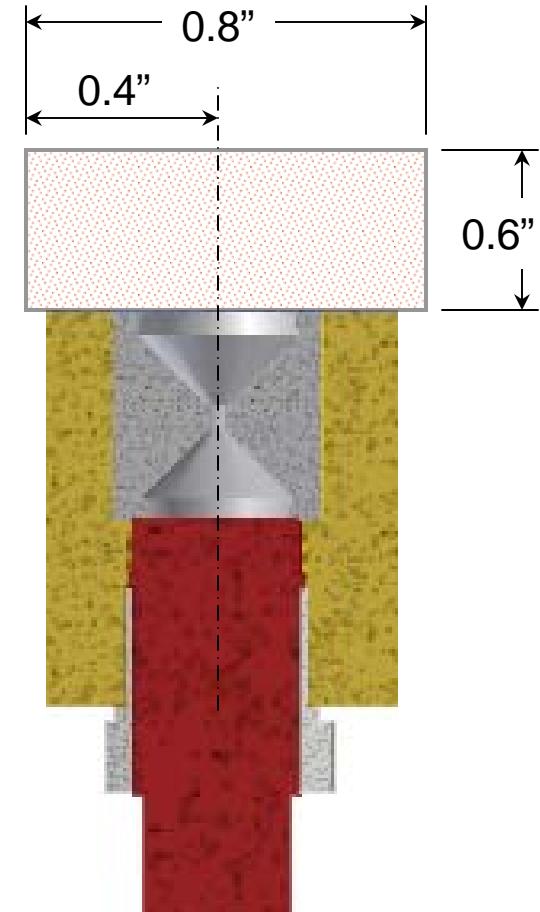
ISC-4



ISC-5



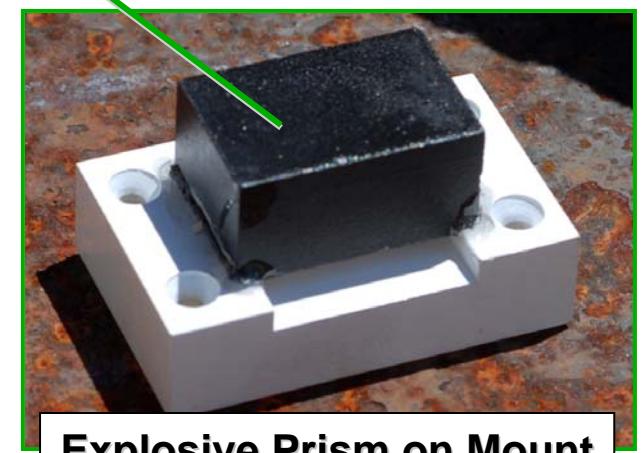
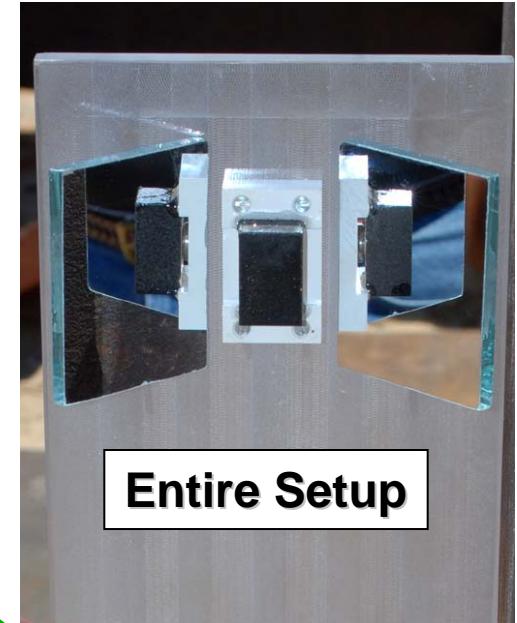
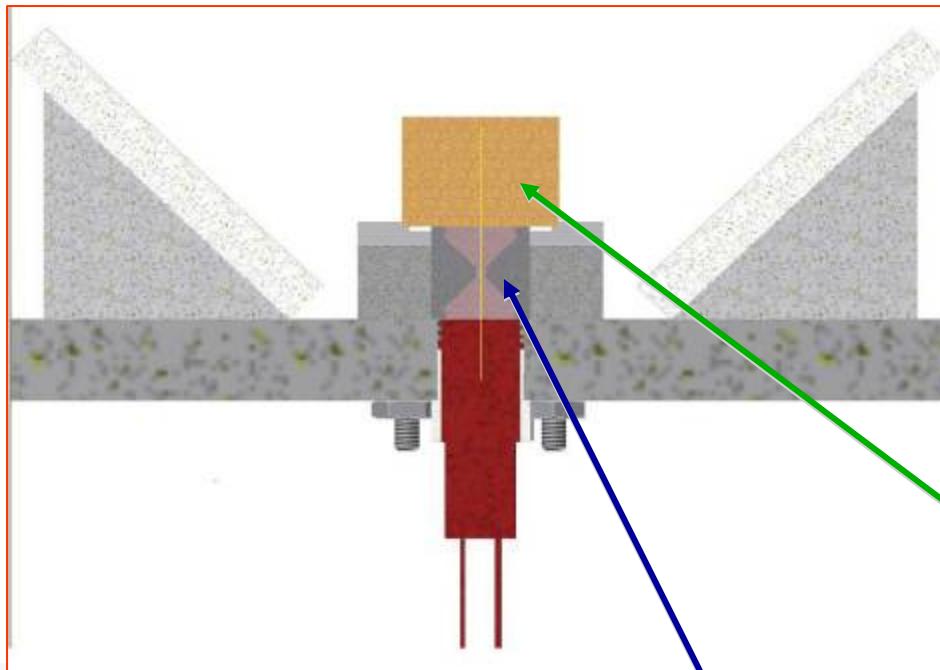
ISC-7 & ISC-8





# Characterization Experiments

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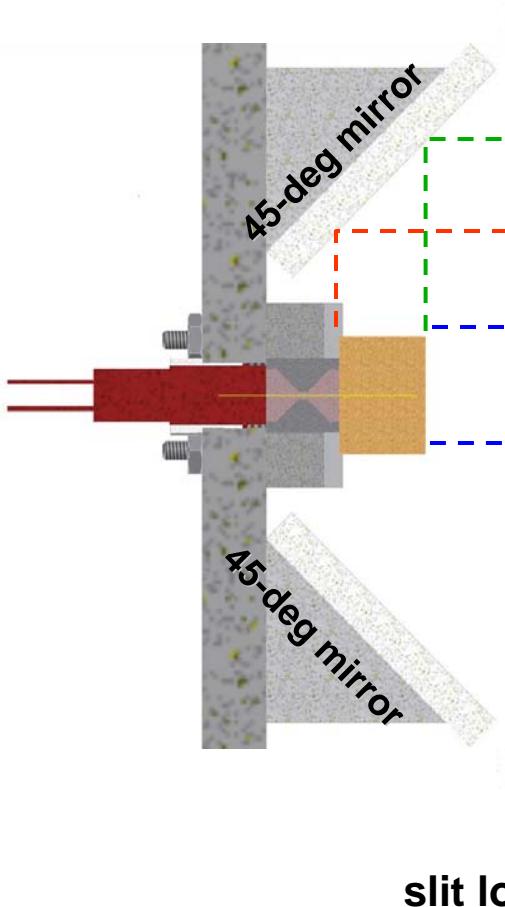




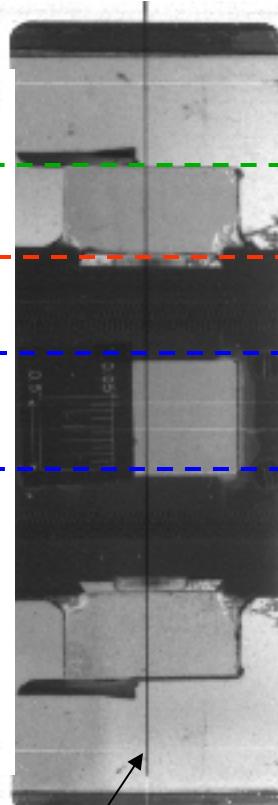
# Example Streak Film (PBX-9501)

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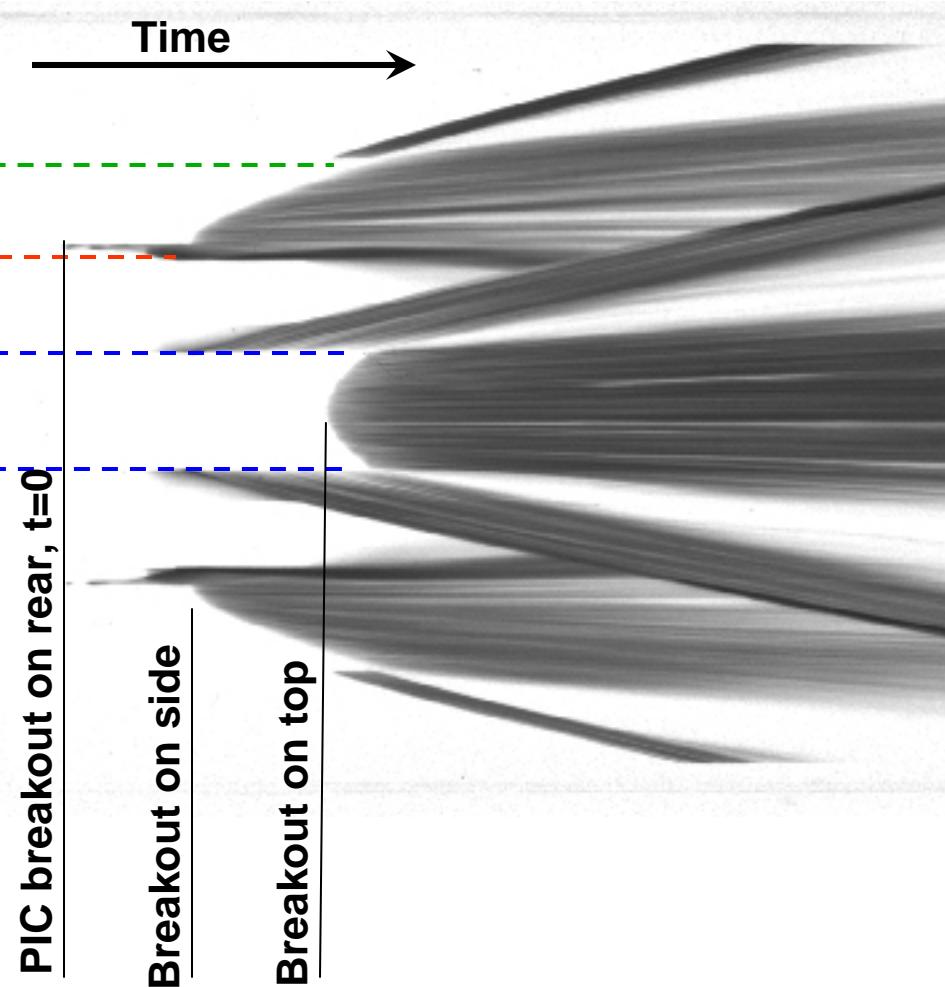
Cross-Section



Static Image



Dynamic Image



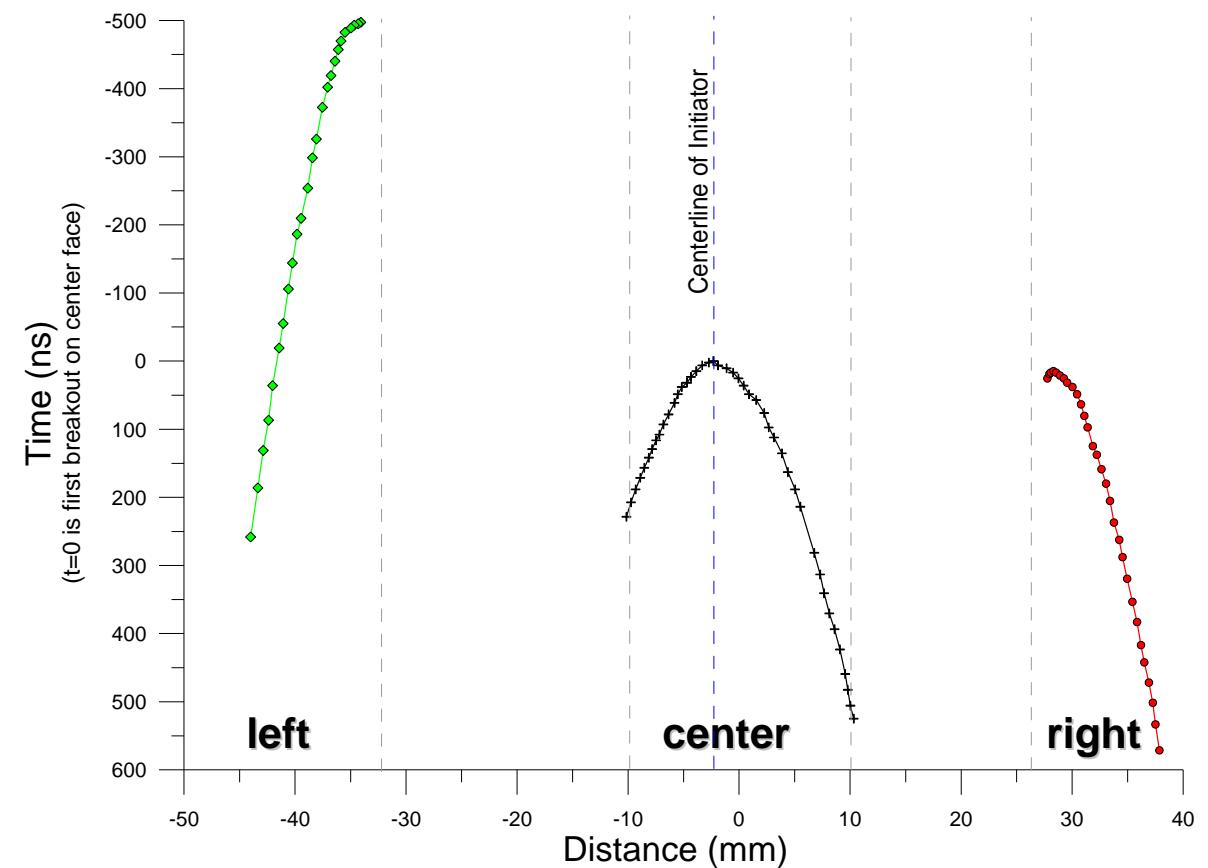
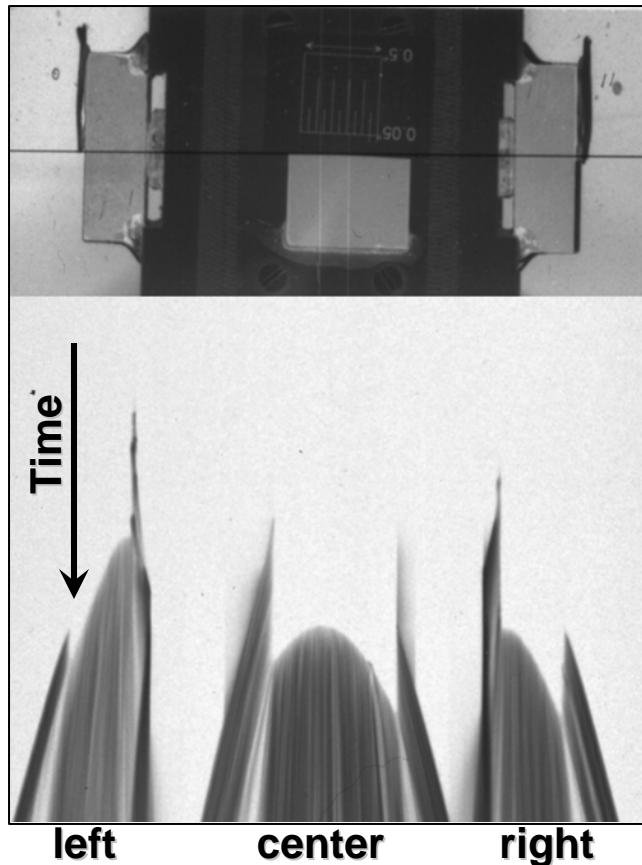


# PBX-9501 w/ RP-1/PIC Initiator



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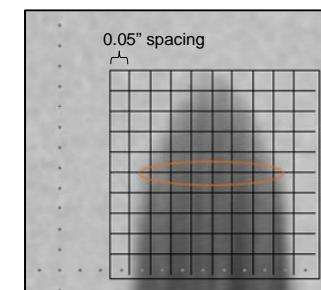
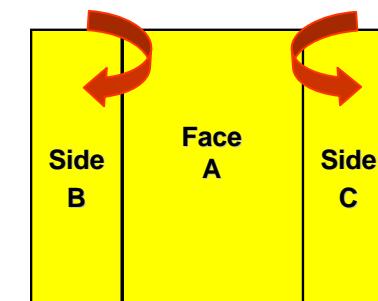
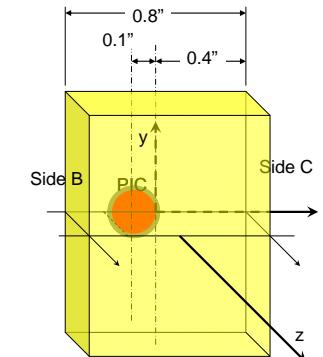
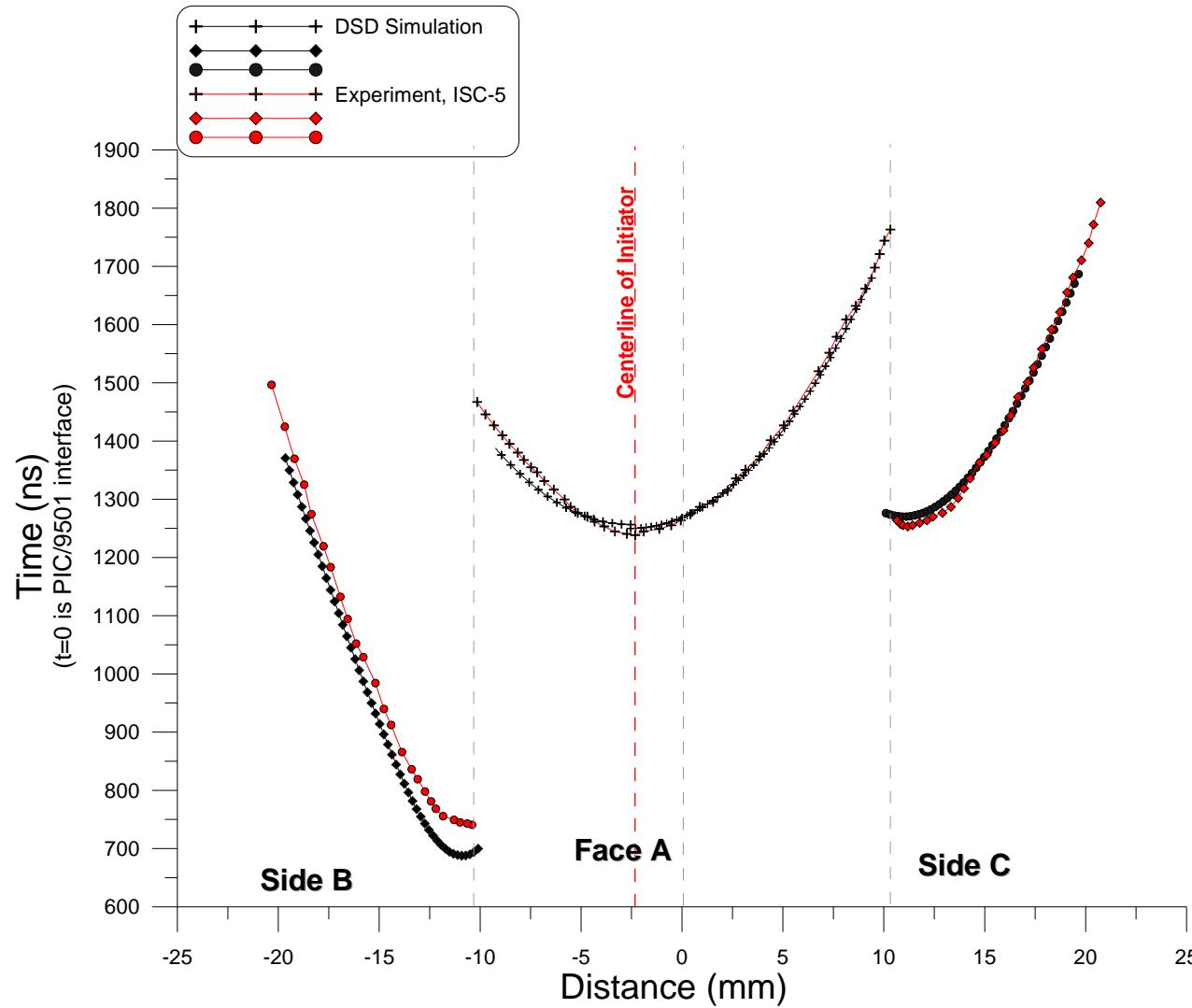
- RP-1/PIC “Research” initiation system offset from charge centerline by 0.10-inch (2.54mm) towards the ‘left side’
- Response, lateral lobes, is a nearly ideal detonation





# ISC-5 Comparison w/ DSD

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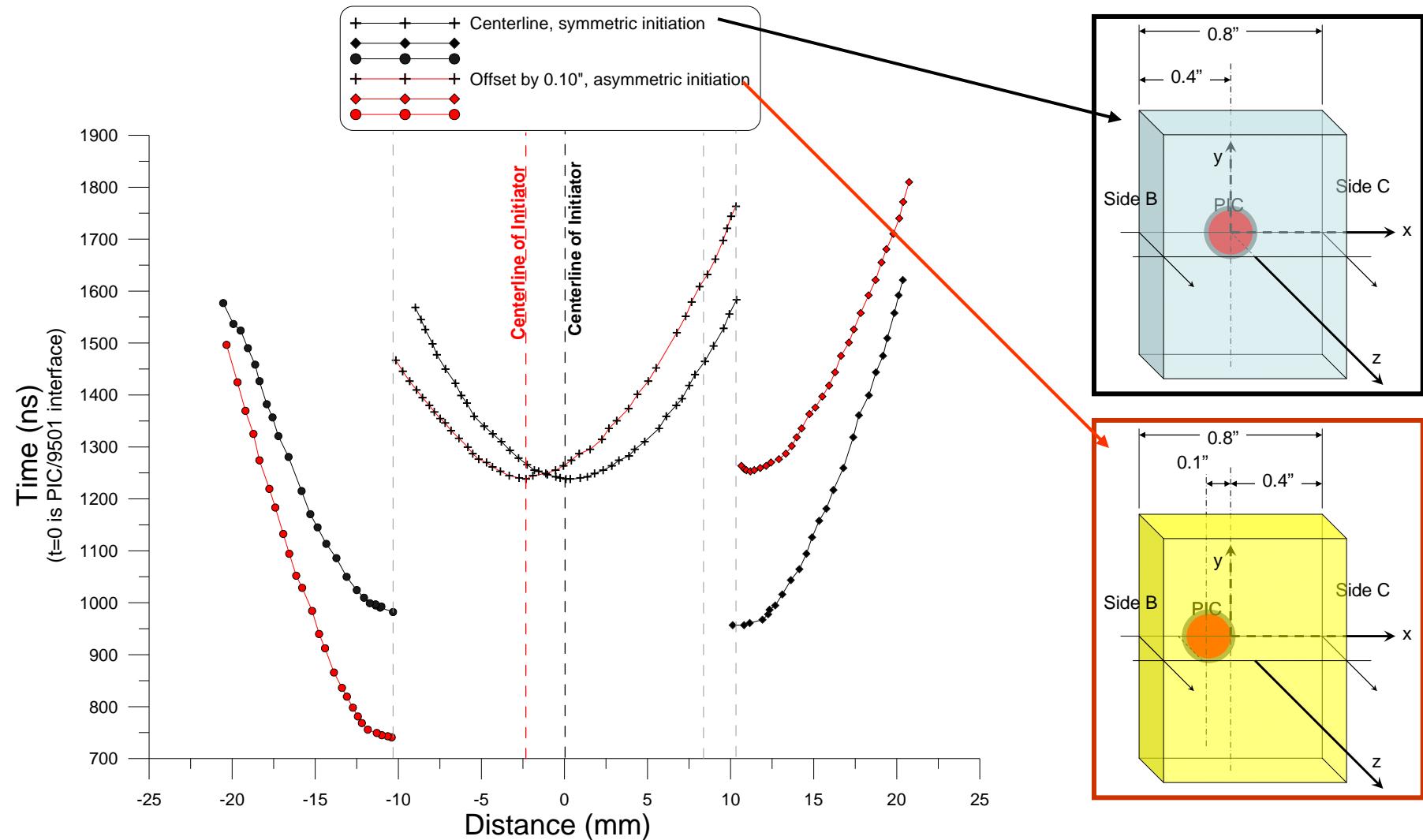


PIC  
output



# Symmetric and Offset Initiation

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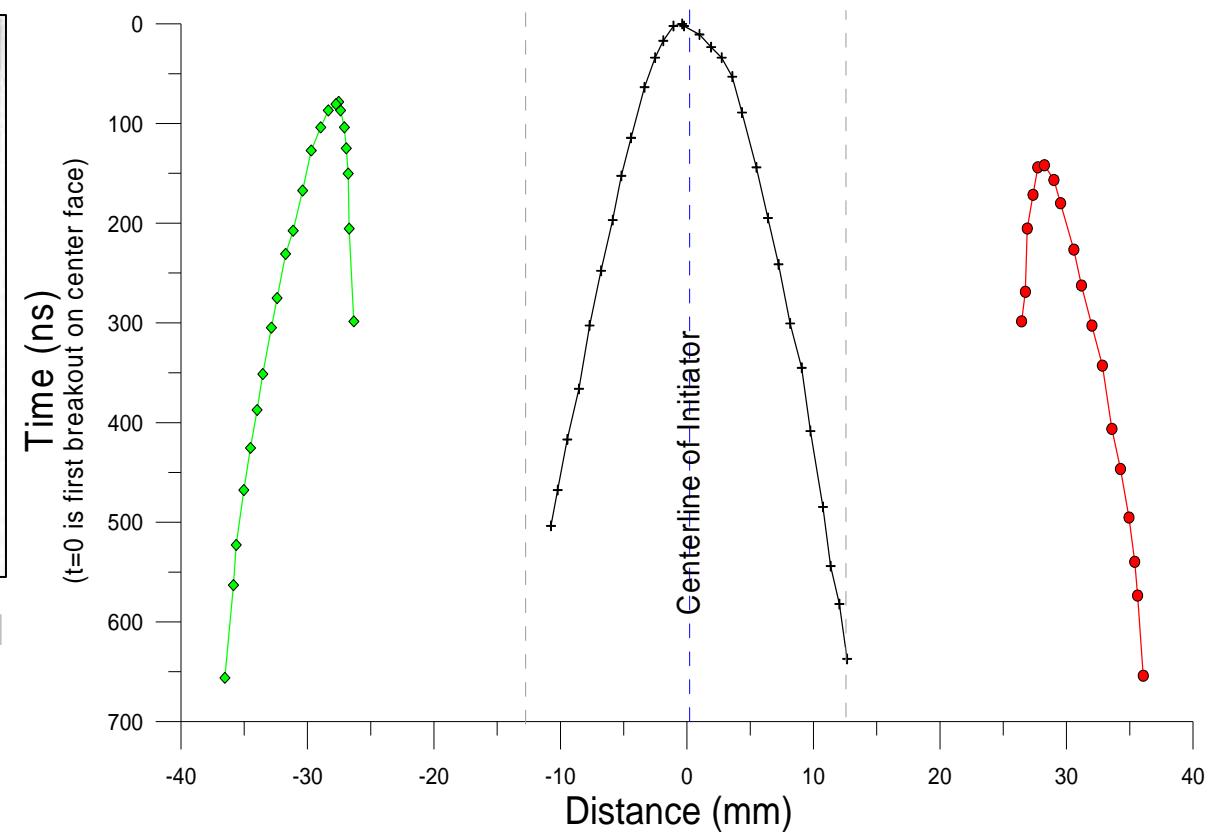
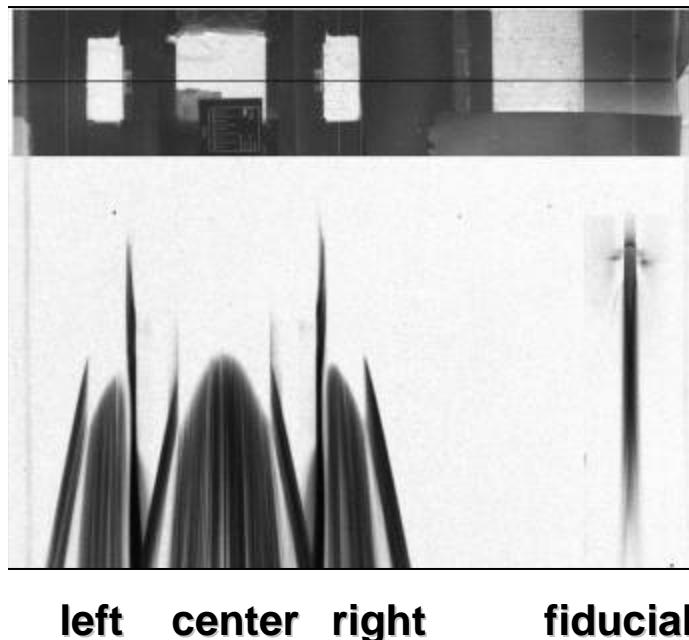


# PBXN-9 – Non-Ideal Response (shot ISC-100)



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- PBXN-9 Explosive prism, 10-mm height (25mm x 25mm)
- Delayed corner turning



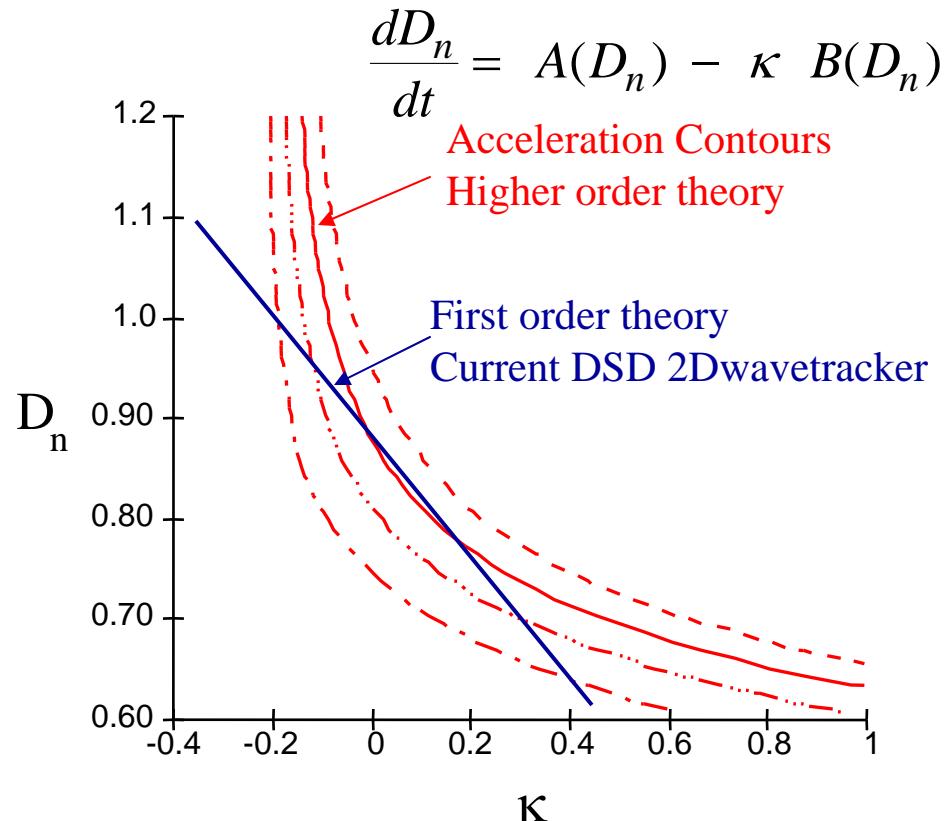


# Working Towards Diffraction and Transient Detonation States



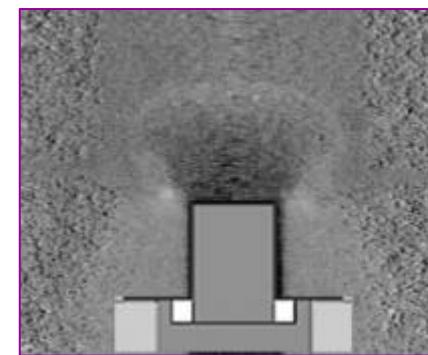
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## $D_n$ - $\kappa$ Curves for Nonideal EOS

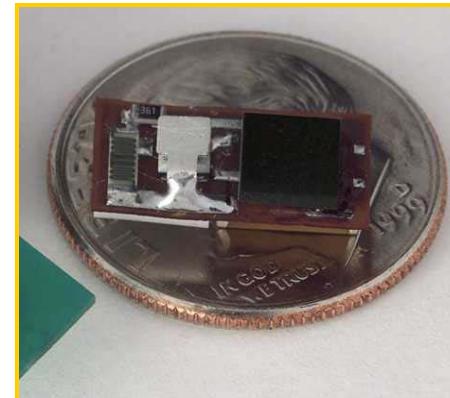


→ The extended theory leads to  $\dot{D}_n, D_n, \kappa$  relation and produces hyperbolic PDE's

- Application to miniaturized detonators
- Understanding initiation criteria
- Diffraction of the detonation



Eric Ferm, LANL, DX Division





# Summary

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- Characterizing the initiation shock transfer, 'Birth of the Wave' is being used to validate the prior assumptions for DSD simulations
- Initial input radius created by the precision initiation coupler (PIC) is under study for analysis of these experiments
- Developing engineering prescriptions of initial shock radii using DSD-based simulations
  - 'Ideal' PBX-9501 shows no corner-turning delay, 'non-ideal' PBXN-9 does show delays in the corner-turning
- Further analysis and extension on these experiments will be a part of transient detonation and shock profile measurements